Sexual Dimorphism in the Labrid Fish *Pseudolabrus celidotus* (Bloch and Schneider) 1801

J. H. CHOAT[1]

DURING A SYSTEMATIC STUDY of New Zealand fishes belonging to the genus *Pseudolabrus* Bleeker 1861, it was observed that one of the commonest species, *P. celidotus,* occurred in two distinct colour phases. This was first noted by Richardson (1848) who described the two colour variants as separate species. The subsequent literature did not recognise these as species, but merely as varieties, although the true relationship was not clarified. A study of populations of this species, both in the field and in the laboratory, revealed that the colour differences were due to sexual rather than environmental or geographic factors, and represented a moderately developed degree of sexual dimorphism. An attempt has been made here to examine the relative proportions of each colour phase in selected populations, the sequence of transition from one colour phase to the other, and the sizes at which transition occurs.

The specimens required for the study were obtained by a variety of quite orthodox methods, lining, spearing, trapping, and various netting techniques all being employed. Rotenone was successful in obtaining small specimens from enclosed rock pools but was less effective in open water.

The genus *Pseudolabrus* comprises a number of predominantly temperate water labrids, the majority of which occur in the coastal waters of New Zealand, Tasmania, and Southern Australia. They are almost completely absent from waters supporting coral reef formations although they have obvious affinities with the tropical Indo-Pacific labrids. *P. celidotus* shares the following characters with the majority of other members of the genus: D. IX/11; A. III/10; operculum fully scaled; a series of small imbricate scales on the cheek; two pairs of anterior canines in each jaw; a posterior canine in each angle of the jaw; an inferior pharyngeal bone bearing a strongly developed anterior shaft; a continuous lateral line.

For the purposes of this study the colour phases were designated simply Phase A and Phase B. The characteristics of each follow. (In each case the descriptions have been furnished from fresh material.)

Phase A (Fig. 1)

General body colouration ranging from pale whitish grey to yellowish green, usually with a black centre in each scale, these becoming more pronounced dorsally. Dorsum varies from dusky grey to black with the interorbital and occipital regions darker than the rest. Throat, isthmus, thoracic, and abdominal regions range from almost white to pale yellow, the sides of the abdomen often shaded by a reddish tint. A single prominent black blotch below the seventh to ninth dorsal spines, extending one scale row above and two scale rows below the lateral line, and covering the ninth to twelfth lateral line scales. Four dark transverse bars on the posterior portion of the body, often becoming indistinct in specimens exceeding 150 mm T.L. The first bar extends from just below the lateral blotch to a point level with the peduncle of the pectoral fin. The second extends from below the sixth to seventh dorsal rays to three or four scale rows below the midline of the body. The third extends from just below the termination of the dorsal fin to the region of the termination of the anal fin. The fourth bar is often diffuse and indistinct, and usually covers the last two or three transverse rows of scales on the caudal peduncle. Two prominent black postorbital bars, the first extending from

[1] Department of Zoology, University of Queensland, Brisbane. This study was carried out at Victoria University, Wellington, New Zealand, and constitutes a portion of a thesis towards the degree of M.Sc. Manuscript received October 18, 1963.

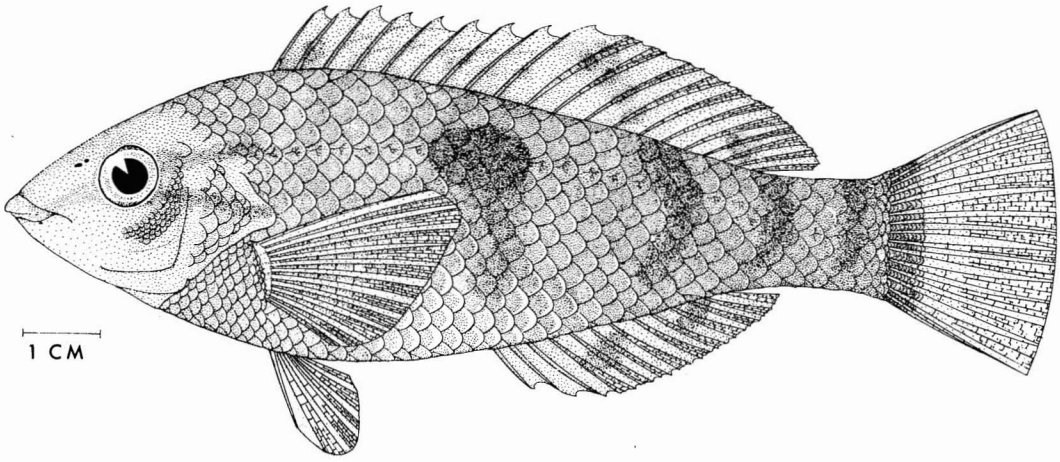

FIG. 1. *Pseudolabrus celidotus* (Female). Colour Phase A.

the mid level of the eye back to the level of the lateral line, the second extending from the lower posterior border of the eye across the operculum to the opercular membrane. A single black bar extending from the anterior margin of the eye to the edge of the maxillary.

Dorsal fin membrane pale to dusky, often becoming faintly yellowish where it invests the spines. Groups of small dark spots occur in the region of the first, second, fifth, and seventh spines, and in the first to fourth and eighth to ninth dorsal rays. Anal fin yellow to orange with two prominent black spots, the first on the first to third rays and the second on the sixth to ninth rays. Caudal and pectoral fins range from very pale translucent yellow to colourless. Ventrals range from pale yellow to orange.

Phase B (Fig. 2)

Background colouration is generally similar to Phase A, although the dark tints on the dorsum and at the centre of each scale are not so pronounced. The body scales, especially in the anterior region, are often marked with bright blue ocelli which tend to fade rapidly

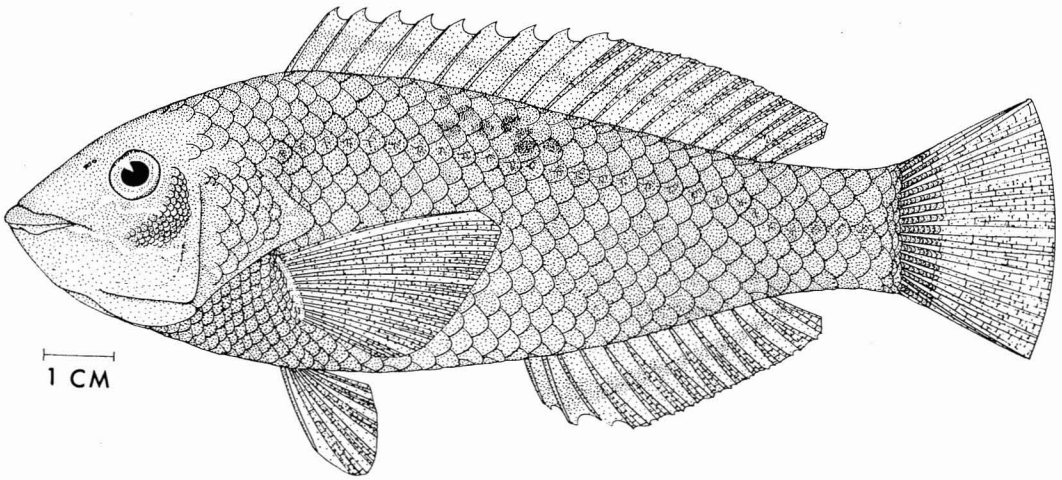

FIG. 2. *Pseudolabrus celidotus* (Male). Colour Phase B.

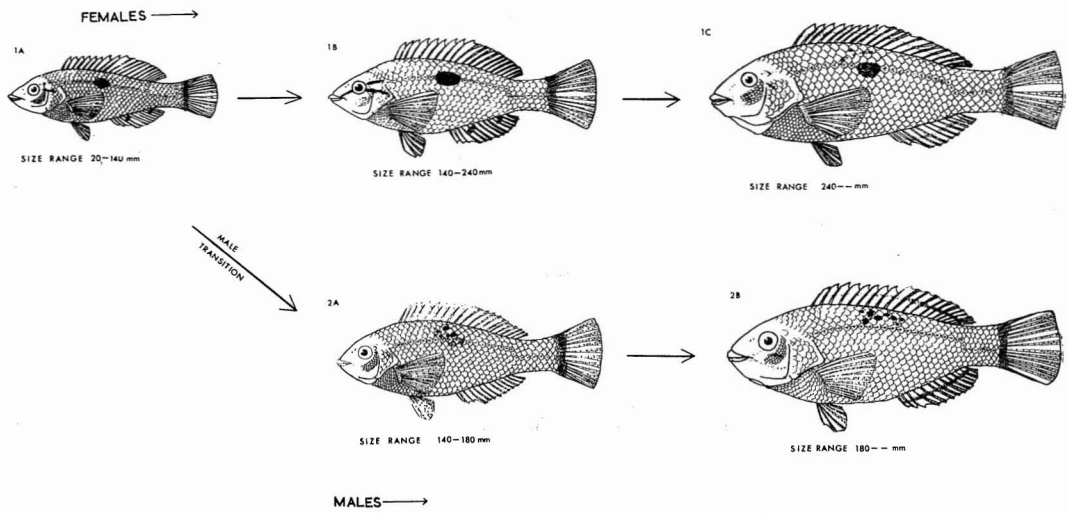

FIG. 3. General sequence of colour transition in males and females of *P. celidotus*. The lengths given must be regarded as being approximate only. It is inferred that sexual transition occurs in the upper limits of the 20–140 mm size range. *1C* demonstrates the gradual development of the B colour pattern by females above 240 mm T.L. *2A* shows the development of the B colour pattern at the expense of the A pattern in males between 140–180 mm T.L.

after death. The sides of the abdomen often with a pronounced reddish orange tint. Anterior and posterior orbital bars, black lateral blotch, anal fin spots, and the black transverse bars on body are lacking. A brilliant blue broken or unbroken line runs from the corner of the mouth to the lower anterior rim of the eye. This line may extend beneath the eye and across the upper series of cheek scales. A blue line extends horizontally from the lateral lobe of the lower lip to the vertical limb of the preoperculum. Both these lines may be reduced to a linear series of dots. Operculum with a scattering of bright blue dots. The dorsum with a series of black dots just above the lateral line, extending from the region just below the sixth dorsal spine to the second dorsal ray. These may tend to become slightly coalesced, and in larger specimens may extend some distance below the lateral line, giving the impression of an indistinct dusky transverse band.

The dorsal fin lacks the groups of dark spots seen in the A phase and is usually a pale yellowish green with a faint orange median longitudinal stripe. Anal fin lacking the two prominent dark spots but displaying a median longitudinal yellowish stripe on a pale whitish green background. The ventrals are usually pale yellow.

Transitional Stages Between the Two Colour Patterns (Fig. 3)

On examination of a series of specimens ranging from 140 to 180 mm T.L., it was found that some exhibited colour patterns that were intermediate between the two phases. These comprised, in the main, specimens showing a definite B colour pattern but still retaining vestiges of the A pattern. The most common manifestation of this consisted of the dark lateral blotch being very faintly represented, with the cluster of black dots characteristic of the B phase strongly superimposed on it. In these specimens the suborbital and opercular blue linear markings were only faintly developed, and traces of the dark postorbital bars could still be detected. Transitional specimens invariably lacked the dark spots on the anal fin, displaying instead the longitudinal stripe of the B phase.

One specimen showing transitional characteristics was considerably larger (240 mm T.L.) than any others. This appeared to have a nor-

mal A colour pattern, although the anal spots were replaced by a longitudinal stripe. On closer examination faint traces of the black lateral dots and the blue opercular marks of the B phase could be detected.

Approximately 400 specimens were examined both in the field and in the laboratory. The results are presented below under the relevant headings.

Correlation of Sex and Size With Colour Pattern

Data concerning the size range, sex, and colour pattern of a range of specimens are presented in Figures 4 and 5. These data are based on an examination of the colour pattern and gonads of 399 specimens ranging from 71 to 255 mm T.L. This investigation revealed the following facts:

(1) Of the 399 specimens examined 280 were females, 105 males, and 14 could not be sexed due to decomposition of the viscera.

(2) The smallest female measured 71 mm T.L., the largest 240 mm T.L.

(3) The smallest male measured 104 mm T.L., the largest 255 mm T.L.

(4) Of the 280 females 279 exhibited a typical A colour pattern, and one specimen 240 mm T.L. exhibited a pattern transitional between A and B.

(5) Of the 105 males 94 exhibited a typical B colour pattern, six exhibited an A pattern, and four appeared to be transitional between A and B. (In Figure 4 it was found necessary to include specimens exhibiting transitional colour patterns as belonging to that group with which their pattern showed the strongest affinity.)

(6) Those exhibiting transitional colour patterns ranged from 141 to 177 mm T.L., except for one female 240 mm T.L.

(7) The six male specimens exhibiting an A colour pattern ranged from 104 to 149 mm T.L., and all contained well developed and apparently functional testes.

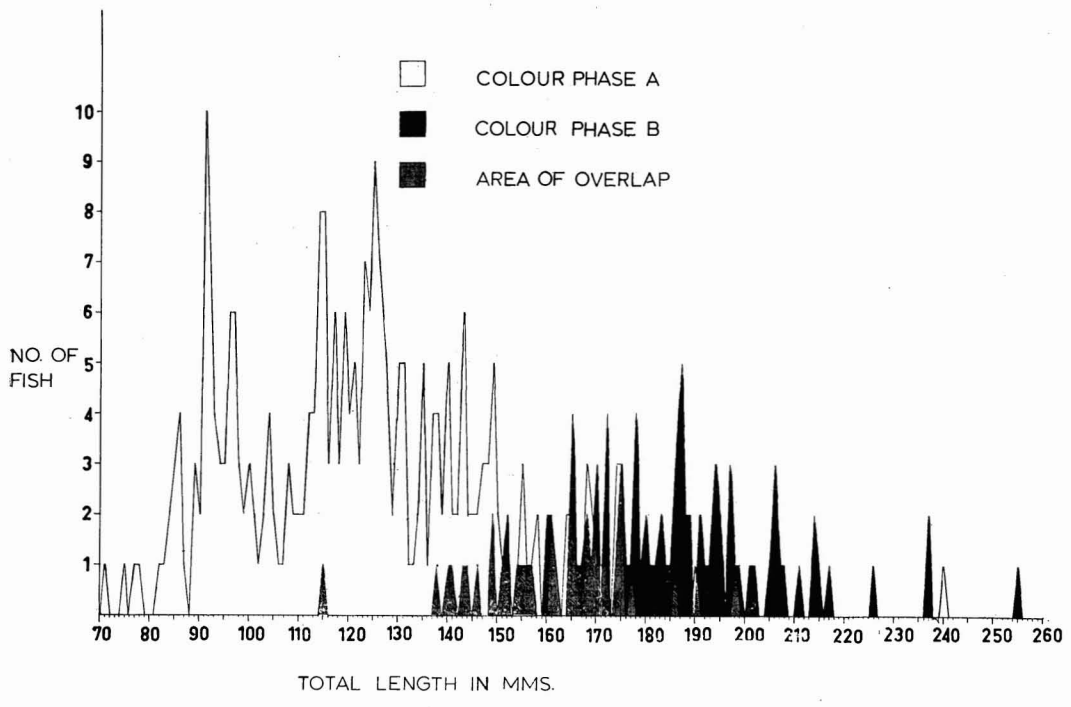

FIG. 4. Relationship of colour pattern exhibited to total length.

The main conclusions appear to be:

(a) A close relationship exists between the sex of each specimen and the colour pattern displayed.

(b) The B colour pattern is assumed by males on reaching a size of 140 to 180 mm T.L. A certain amount of variation can be expected as to the actual size at which the pattern becomes apparent. One male measuring 115 mm T.L. displayed a well developed B pattern.

(c) The males are capable of developing functional testes before the B pattern appears.

(d) Mature females in excess of 240 mm T.L. may assume the B colour pattern.

Paucity of Males

One of the most notable disclosures of this study was the paucity of males smaller than 104 mm T.L. Large numbers of specimens between 70 and 130 mm T.L. were examined, but of 201 individuals only four were males. Collections, using a variety of methods, were made over the full range of habitats known to be occupied by this species, and it is difficult to assume that the lack of small males reflects a highly selective factor in the sampling techniques.

The most tenable explanation for the comparatively sudden appearance of males in the population is that this is a progynous species, with all individuals commencing life as females. Such a possibility was indicated by Stoll (1955: 130), who studied the influence of hormones on the colour phases of the labrid *Thalassoma bifasciatum.* This situation may well obtain in *Gomphosus varius,* as Hiatt and Strasburg (1957:133) discovered no males smaller than 104 mm S.L.

Because this study was only an appendage to a systematic revision of the genus, there was insufficient time to initiate a conclusive study into the reproductive micro-anatomy and the effects of hormonal extracts.

In Figure 3 a general sequence of colour transition is presented. Inasmuch as no males smaller than 104 mm were discovered, and as those male specimens displaying an A colour pattern appeared to have functional testes, it was concluded that sexual transition generally occurs at approximately 130–140 mm, before the development of the B colour pattern.

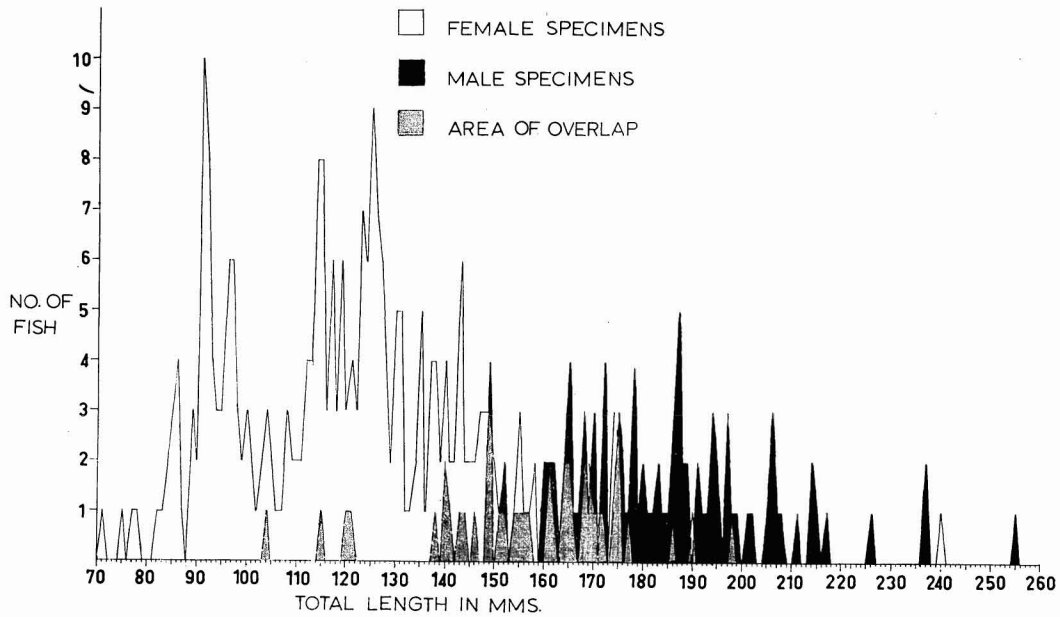

FIG. 5. Relationship of sex to total length.

Structural Changes Associated with Change of Colour Pattern

These changes did not appear to be entirely due to sexual dimorphism and may have been influenced by developmental factors. The most striking changes are seen in the adult male, in which the profile of the head becomes increasingly obtuse. In many cases the convexity of the upper and lower profiles of the head is developed to such a degree that the appearance of the head is completely altered. Such changes also occur, although to a lesser degree, in large females. In large males the upper limb of the preoperculum is more nearly vertical than that of the female, this probably being due to the increased obtuseness of the snout and the proportional changes associated with it.

Disjunctive Distribution of the Sexes

Adult males were usually obtained only from deeper water. The fact that shallow water collecting stations (especially over sandy bottoms in the vicinity of wharves and docks) revealed mainly females between 70 and 200 mm T.L. was thought at first to be due to a size selection factor imposed by the gear used. However, underwater observation confirmed the supposition that this habitat was populated mainly by individuals not exceeding 200 mm T.L. and displaying an A colour pattern. A few individuals approximately 200 to 240 mm T.L. displaying a B pattern were seen, but these were rather exceptional. Collection from deeper water (in the order of six fathoms), away from the vicinity of wharves and shoreline rocks, revealed the presence of a much larger population of large fish, the majority of them being males. This situation obtained in most habitats sampled but was more pronounced in sheltered bays and harbours with a uniform sandy bottom.

Hiatt and Strasburg (1957:133) record a rather similar situation in their work on *Gomphosus*. The adult male or *"tricolor"* phase was observed mainly in the deeper parts of the range and was uncommon even there. This was confirmed by the author while making field observations at Heron Island on the Barrier Reef. Such a distribution is even more pronounced in the case of *Stethojulis strigiventer*, which Randall (1955) has shown to be sexually dimorphic. The immature and adult females bearing the *"strigiventer"* colour pattern were found to be common on the reef flat during both high and low water and, indeed, represented one of the most abundant species noted there. The adult male or *"renardi"* phase appeared to be almost absent from the reef flat and, although observed in reef crest pools and on the outer slope, was nowhere abundant.

SUMMARY

(1) The temperate labrid fish *P. celidotus* occurs in two distinct colour phases which, for the purposes of this study, have been designated Phase A and Phase B.

(2) Specimens displaying a colour pattern transitional between A and B are observed.

(3) Examination of the colour pattern, gonads, and size range of a series of specimens indicates that the colour differences are due to sexual dimorphism.

(4) The B colour phase is characteristic of sexually mature males larger than 160 mm T.L.; the A colour phase is characteristic of immature and mature females smaller than approximately 240 mm T.L. and some mature males smaller than 160 mm T.L. Females larger than 240 mm T.L. may assume the B colour phase.

(5) A notable feature is the lack of males below 104 mm T.L. It is postulated that the species is progynous and that all specimens below 100 mm T.L. are females.

(6) The sexes have a disjunctive distribution, adult males being usually confined to the deeper parts of the range, usually in excess of 4–5 fathoms.

REFERENCES

HIATT, R. W., and D. W. STRASBURG. 1957. Sexual dimorphism in the labrid fish Genus *Gomphosus*. Pacific Sci. 11(1):133–134.

HUTTON, F. W. 1904. Index fauna Novae Zealandiae. The fishes, pp. 40–55. Government Printer, Wellington.

KINOSHITA, Y. 1934. On the differentiation of the male colour pattern and sex ratio in *Halichoeres poecilopterus* (Temm. and Schl.). J. Sci. Hiroshima Univ. Ser. B, Div. 2, Vol. 3, 65–76, 3 plates, 2 text figs.

MCCULLOCH, A. R. 1921. Studies on Australian fishes, 7. Australian Mus. Rec. 13:123–142.

RANDALL, J. E. 1955. *Stethojulis renardi,* the adult male of the labrid fish *Stethojulis strigiventer.* Copeia (3):237.

RICHARDSON, J. 1848. Ichthyology of the Voyage of the H.M.S. "Erebus" and "Terror." 139 pp., 60 plates.

STOLL, L. M. 1955. Hormonal control of the sexually dimorphic pigmentation of *Thalassoma bifasciatum.* Zoologica 40(3):125–131, 3 plates.

WAITE, E. R. 1911. Scientific results of the New Zealand Government Trawling Expedition, 1907. Rec. Cant. Mus. 1(3):157–272, 34 plates.